Evidence of Organic Pollution Observed in Ebrié Lagoon around Abidjan City (Côte d’Ivoire)

Abstract: Surface waters are precious natural resources because of their several socio-economic opportunities and activities occurred (fishing, maritime transport, industrial, agriculture, etc.). Unfortunately, worldwide, the majority of wastewaters generated by these activities are rejected in the environment without any proper treatment. This investigation was carried out from February 2008 to December 2009 during which water samples were collected at eighteen sites to highlight the urban pollution impact on Ebrié Lagoon waters. The samples were analyzed according to standard methods for amount of Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD₃) and Chemical Oxygen Demand (COD). Concentrations of DO were ranged from 0.81±0.65 to 7.26±2.24 mg/L, whereas COD and BOD₃ values were respectively found in the ranges 100.28±38.41-1900.00±60.79 mgO₂/L and 40.75±18.96-964.18±844.08mgO₂/L. The COD:BOD₃ ratio was ranged from 1.40 to 14.67. Hypoxia conditions were observed for all samples collected in bays closed to Abidjan City. DO, COD and BOD₃ levels were found unsuitable for aquatic life with significant differences (p < 0.05) between locations. Seasonal variations were also observed for the three pollution indicators used. The data have revealed the necessity of the Ebrié lagoon preservation because of its importance, requiring the control and treatment of effluents prior their introduction into its waters.

Keywords: Dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, Ebrié lagoon.

I. Introduction

Due to the key role of water for human activities, coastal regions have always been the most heavily populated areas throughout the world. In Côte d’Ivoire, Abidjan is the economical capital with more than 20 % of the total population of the country. Nearly 80% of the whole industries of the country are also closed to Abidjan City, due to the facilities offered by Abidjan Port. These industries are generally built on the Ebrié Lagoon banks. Worldwide, the towns, often situated at the mouth of a river or the opening of a lagoon, associated with intensive urbanization, industrialization, farming, port activities, etc. have gradually led to serious environmental changes and degradations of these environments, when wastes from these activities are not correctly treated prior their input in surface waters. Lagoons, estuaries and areas near the continental shelf are important zones for several marine organisms. Indeed, due to their probably trophic richness and relative shelter, they are often spawning and fattening zones, stages during migrations or simply transit places for continental shelf fish. Even if a few species remain in them throughout their lives, many spend their juvenile stages there (Longhurst and Pauly, 1987).

In Côte d’Ivoire, all wastewaters (domestic, industrial, agricultural, port activities, etc.) from Abidjan city and its agglomeration are introduced in Ebrié lagoon waters without any treatment or in a best case, after summarily treatment. Such wastes are known as vectors of many pollutants (nutrients, heavy metals, organic components, etc.) (Monou et al., 2010; Adama et al. 2012; Adama et al., 2013). These pollutants seriously threaten the balance of aquatic ecosystems. Furthermore, the decomposition of organic matter causes the emission of very obnoxious and unpleasant odors (often associated with hydrogen sulfide presence) for local communities. Products of organic matter mineralization such as nutrients are also involved in waters eutrophication. This phenomenon can often lead to dissolved oxygen concentrations decrease, reduction of waters transparency and photosynthesis activity, harmful conditions for many aquatic organisms (fishes, mollusks, etc.) (Fry, 1971; Tom, 1998; Priyanka and Sujata, 2014). Several accidental deaths of fishes are regularly observed in the Ebrié Lagoon, particularly in Biétri Bay, one of the most polluted bays of the Ebrié Lagoon (Guiral and Chantraine, 1983). These episodes of massive mortality were generally observed during upwelling periods, following with the decrease of dissolved oxygen levels in the water column. Carbon dioxide, methane, etc. are products of the
degradation of organic matters introduced in surface waters and known as greenhouse gas, therefore involved in climate changes. Organic matters mineralization can also release some highly toxic substances such as heavy metals, leading to recontamination of the water column, threatening many aquatic organisms’ lives. Indeed, organic materials are preferred carriers for many toxic substances such as heavy metals. Even if organometallic complexes thus formed are relatively stable, at long-term, they constitute a real threat for benthic organisms due to bioaccumulation of metals in the food chain via respiration, absorption and ingestion (Zhou et al., 2001).

Waters contamination with metals is a threat to human health and the whole environment (Igwe and Abia, 2006). Such as heavy metals, many organic components (Persistent Organic Pollutants (POPs), pesticides, etc.) are responsible of physiological and biological disturbances to marine organisms. Previous studies have shown a level of metallic and organic pollution of waters and sediments collected in the Ebrié Lagoon for several bays closed to Abidjan city (Kone et al., 2008; Yao et al., 2009; Bakary et al., 2009; Monou et al., 2010; Adama et al., 2012; Adama et al., 2013).

Dissolved oxygen (DO), Chemical oxygen demand (COD) and Biological oxygen demand (BOD5) are widely adopted as a measure of general pollution effect, and particularly, for organic pollution assessment (Dufour 1982, Jean et al., 1980; Yao et al., 2009; Monou et al., 2010, Priyanka and Sujata, 2014; Abdelmalek et al., 2014). However, there are no data regarding spatial and seasonal study regarding the whole estuarine part of the Ebrié lagoon. The present study was conducted to assess spatial and seasonal variations of organic pollution in both surface and bottom waters of the urban area of the Ebrié Lagoon. Further, COD:BOD5 ratio was used to assess the self-purification capacity of studied area and the suitability of Ebrié Lagoon waters to support aquatic life and domestic supply.

II. Materials and Methods

A. Study Area

The Ebrié Lagoon has an area of 566 km2 and stretches on 125 km along the coast of Côte d’Ivoire, between 3°40’ and 4°50’ West, at latitude 5°50’ North (Table 1)(Dufour, 1982; Adama et al., 2012). It communicates with the Atlantic Ocean by the Vridi channel, drilled in 1951, for the building of Abidjan Port, the most important in West Africa. Names and GPS coordinates of the sampling sites in are presented in table 1. Ebrié Lagoon waters are simultaneously diluted with marine waters during dry seasons and with fresh waters (from coastal rivers, mainly Comoé River) during the rainy and flood seasons.

Table 1: Names and GPS coordinates of the sampling sites.

<table>
<thead>
<tr>
<th>Bay</th>
<th>Site</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Bay</th>
<th>Site</th>
<th>Latitude</th>
<th>Longitude</th>
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<td>4°01.946’</td>
<td>Biëtri</td>
<td>SIR</td>
<td>5°16.149’</td>
<td>3°59.358’</td>
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<tr>
<td></td>
<td>Sebroko</td>
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<td>4°02.183’</td>
<td>Bidet</td>
<td></td>
<td>5°15.598’</td>
<td>3°58.511’</td>
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<tr>
<td></td>
<td>Bolibana</td>
<td>5°21.750’</td>
<td>4°02.548’</td>
<td>Abattoir</td>
<td></td>
<td>5°15.890’</td>
<td>3°58.333’</td>
</tr>
<tr>
<td>Cocody</td>
<td>Hôtel-Ivoire</td>
<td>5°19.396’</td>
<td>4°00.565’</td>
<td>Unilever</td>
<td></td>
<td>5°16.970’</td>
<td>4°00.203’</td>
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<td></td>
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<td>4°00.898’</td>
<td>SIVOA</td>
<td></td>
<td>5°17.284’</td>
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<td></td>
<td>Stade FHB</td>
<td>5°19.774’</td>
<td>4°01.025’</td>
<td>Marina</td>
<td></td>
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<td>4°00.071’</td>
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<td>4°04.638’</td>
<td>Marcory</td>
<td>Grand Caniveau</td>
<td>5°18.666’</td>
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<td></td>
<td>S2</td>
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<td>4°04.744’</td>
<td>Biafra</td>
<td></td>
<td>5°18.898’</td>
<td>4°00.383’</td>
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<td></td>
<td>S3</td>
<td>5°16.989’</td>
<td>4°04.896’</td>
<td>Bingerville</td>
<td>Ana Extension</td>
<td>5°19.500’</td>
<td>3°53.590’</td>
</tr>
</tbody>
</table>

B. Collection of Water Samples

For the present study, 216 samples were collected at bimonthly intervals in surface and bottom waters from February 2008 to December 2009. Eighteen (18) sites located at a mean distance of 25 to 50 m from domestic and/or industrials inputs were chosen according to their accessibility and effluents nature (Table1). The exact position of each sampling site was recorded using Global Positioning System (GPS) (Table 1). Samples were collected according to standards methods (APHA, 2005; Adama et al., 2012).

C. Analysis of Water Samples

BOD5 is the amount of oxygen consumed by the oxidizable material using bacteria acclimated for a period of five (5) days of incubation at 20 ° C. Its determination was made according to the French Normalization Agency (AFNOR, NF T 90-103) (AFNOR, 1994). COD test measures the oxygen demand of the whole oxidizable pollutants contained in the sample. The measurement was performed with the potassium dichromate method according to the Norma NF T90-101 (AFNOR, 1994).

All statistical analyzes were performed with STATISTICA Software (2005, 7.1 Version). Principal Component Analysis (PCA) was performed with ADE-4 Software to capture the similarities and/or differences between the sampling sites.
III. Results and Discussion

A. Spatial Variations of DO, BOD\textsubscript{5} and COD Concentrations

DO, COD and BOD\textsubscript{5} were assessed in Ebrié Lagoon waters. Mean values of the three parameters are presented in Table 2. DO is essential to the ecological balance of aquatic ecosystems. The observed values were ranged from 1.62±1.62 to 7.26±2.24mg/L and from 0.81±1.65 to 5.54±1.14mg/L respectively in surface and bottom waters (Table 2). Mean values of DO were 3.96mg/L and 2.77mg/L in surface and bottom waters respectively. The values obtained for present study are similar to those observed by Bakary et al. (2009) in Milliardiaires Bay and Yao et al. (2009) in bays closed to Abidjan City (Bakary et al., 2009; Yao et al., 2009). With the exception of Cocody and Marcory Bays, DO concentrations met the criteria (> 5mg/L) for surface waters (Table 2) (WHO, 2004). For bottom waters, apart from S3 located in Milliardiaires Bay), the criteria was not met elsewhere (Table 2). Lowest values of DO were observed in Cocody, Marcory and Bietri Bays, three of the most polluted bays located in the urban area of the Ebrié Lagoon. Indeed, organic matter mineralization in waters is generally accompanied with dissolved oxygen consumption, particularly in bottom zones which organic matter is accumulated. The tide also favors surface waters oxygenation through interaction between atmospheric air and surface water at air-water interface as observed in Milliardiaires Bay, more influenced by the tide through Vridi channel. However, lowest levels of DO were observed in closed areas with lowest hydrodynamics, renewal rates and depths. Such observation was observed in Cocody Bay (Stade FHB), in Marcory Bay (Biafra) and in Bietri Bay (SIR, Bidet and Unilever) (Table 2). This is the result of diffuse organic components inputs via different effluents on one hand and, on the other hand, the lowest depths and water renewal rates observed in these confined areas. Lowest concentrations of DO in aquatic ecosystems often lead to potential behavioral responses such as changes in distribution, habitat use, activity, increased use of air breathing, increased use of aquatic surface respiration, and habitat shifts (Priyanka and Sujata, 2014).

BOD\textsubscript{5} is an important parameter used for surface waters organic pollution assessment. Indeed, this parameter is useful for dissolved oxygen decrease prediction in aquatic ecosystems due to oxygen consumption during organic matter mineralization on one hand, and one the over hand, for water self-purification capacity assessment. In Ebrié Lagoon, the values were respectively ranged from 42.04±18.26 to 964.18±44.08mgO\textsubscript{2}/L and from 40.75±18.96 to 316.96±42.07mgO\textsubscript{2}/L in surface and in bottom waters (Table 2). Except for BNETD, Stade FHB and SIVOA, BOD\textsubscript{5} values observed in surface waters were higher than those of the bottom ones elsewhere. The lowest BOD\textsubscript{5} value was recorded at S3, otherwise, the one where DO criteria was met in bottom waters (Table 2). Values observed for present study are higher than those observed by Bakary et al., 2009 and those of the study conducted by Yao et al., 2009.

| Sampling Sites | Surface Waters | | | | | Bottom Waters | | |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
|                | DO             | COD            | BOD\textsubscript{5} | R              | DO             | COD            | BOD\textsubscript{5} | R              |
| CARENA         | 5.15±3.58      | 803.43±51.94   | 114.59±83.95      | 6.97           | 3.49±2.40      | 981.49±852.36   | 66.91±33.73      | 14.67          |
| Sebroko        | 5.02±5.02      | 615.31±54.48   | 132.05±82.65      | 4.66           | 2.45±2.01      | 903.17±700.92   | 95.17±47.84      | 9.49           |
| Bolibana       | 4.19±2.61      | 641.47±56.54   | 134.67±98.97      | 4.56           | 2.44±2.08      | 797.43±504.64   | 120.32±80.96     | 6.63           |
| Hôtel-Ivore    | 3.63±2.34      | 767.60±632.26  | 109.53±17.95      | 7.01           | 4.31±1.11      | 619.00±442.44   | 95.82±39.49      | 6.46           |
| BNETD          | 3.20±2.47      | 565.71±588.38  | 66.56±31.02       | 8.50           | 3.16±1.73      | 673.14±620.62   | 109.40±88.07     | 6.15           |
| Stade FHB      | 1.62±1.61      | 739.53±533.47  | 133.48±100.00     | 5.54           | 2.44±2.02      | 894.00±616.15   | 168.42±51.07     | 5.84           |
| Grand Caniveau | 2.68±2.07      | 479.67±340.20  | 136.25±65.05      | 3.52           | 2.42±1.88      | 762.29±559.67   | 112.58±48.60     | 6.77           |
| Biafra         | 3.57±1.90      | 379.13±367.26  | 270.79±477.97     | 1.40           | 3.90±1.18      | 761.63±496.43   | 117.37±89.98     | 6.49           |
| SIR            | 5.30±3.40      | 383.24±591.64  | 153.38±63.85      | 2.50           | 0.81±1.65      | 852.56±703.18   | 85.64±27.81      | 9.96           |
| Bidet          | 4.23±3.21      | 660.04±634.12  | 155.96±99.47      | 4.23           | 1.21±1.93      | 668.57±506.68   | 65.00±32.05      | 10.29          |
| Ahattoir       | 4.53±3.00      | 644.97±587.16  | 168.24±145.70     | 3.83           | 2.34±2.76      | 795.14±610.53   | 106.43±23.08     | 7.47           |
| SIVOA          | 3.75±3.22      | 571.51±516.97  | 129.76±50.67      | 4.40           | 2.29±2.16      | 642.86±479.86   | 155.53±81.99     | 4.13           |
| Marina         | 5.00±3.25      | 841.94±635.95  | 133.66±101.99     | 6.30           | 4.64±3.40      | 791.43±555.51   | 69.76±39.00      | 11.35          |
| Unilever       | 4.05±2.87      | 688.93±659.32  | 142.00±24.77      | 4.85           | 1.93±2.63      | 562.17±333.31   | 89.11±31.71      | 6.31           |
| S1             | 5.61±0.91      | 1900.00±60.79  | 964.18±448.04     | 1.97           | 3.18±2.61      | 1400.00±44.08   | 316.96±42.07     | 4.42           |
| S2             | 4.37±1.24      | 1400.00±51.61  | 302.50±20.83      | 4.63           | 2.50±2.20      | 1600.00±35.33   | 115.24±16.37     | 13.88          |
| S3             | 7.26±2.24      | 308.80±63.90   | 42.04±18.26       | 7.35           | 5.54±1.14      | 501.28±89.02    | 42.07±26.16      | 11.92          |
| Ana Extension  | 5.16±0.96      | 541.76±59.27   | 125.43±19.38      | 4.32           | 4.37±2.25      | 100.28±38.41    | 40.75±18.96      | 2.46           |
The chemical oxygen demand (COD), unlike the BOD₅ concerns the whole chemically oxidizable compounds in the analyzed sample. In surface waters, the COD values were ranged from 308.80±63.90 (S3) to 1900.00±85.79mgO₂/L (S1). In the bottom zones, the values were ranged from 100.28±38.41 (R) to 1600.00±35.33mg O₂/L (S2) (Table 2). COD values were naturally higher than those of BOD₅ according to the fact that the COD takes into account both biodegradable organic compounds (estimated by BOD₅) than those who did not.

Principal component analysis (PCA) was carried out to examine the pattern of relationship among the three parameters (DO, BOD₅ and COD) values observed in surface and bottom waters, obtained from various sites in Ebrié Lagoon (Figure 1). The first two PCA axes were selected because they explain more than 77 % of the whole information (F1: 53.20%; F2: 24.02 %) of organic pollution in studied waters. The differences and similarities are presented in score plots which display the positions of the samples in the new coordinates (F1 and F2) (Figure 2). The first axis (F1: 53.20%) is well described by COD and BOD₅ parameters, while second one (F2: 24.02 %) is describes by DO levels (Figure 1). Similar samples are located together (Jojas et al., 2005).

The correlation matrix helped to highlight the heterogeneity of the studied area, taking into account both the three parameters used (DO, BOD₅ and COD) on one hand, and one the other hand, considering samples’ depths (Figure 1). For DO, highest contents were observed at S3, Ana Extension and Marina stations, while the lowest were observed at Stade FHB, Grand Caniveau, Bidet and SIVOA (Table 2; Figures 1 and 2). The value of the ratio COD/BOD₅ is usually used for waters natural capacity for organic materials decomposition in surface waters (Yao et al., 2009; Inza et al., 2009). Its values observed in Ebrié Lagoon are presented in table 2.

For surface waters, biodegradable condition in relation with BOD₅ and COD contents is: COD/BOD₅ < 3. For the present study, values observed were ranged from 1.97 (S1) to 8.50 (BNETD) and from 2.46 (Ana Extension) to 14.67 (CARENA) respectively in surface and bottom waters (Table 2). According to the above biodegradable criteria, for surface samples, 16.67 % of samples were biodegradable against only 5.56 % for the bottom ones (Table 2). According to this data, several organic pollutants introduced in Ebrié Lagoon waters were hardly biodegradable. It’s the case of Persistent Organic Pollutants (Pops), Haps, etc., therefore harmful for aquatic life (Alani et al., 2013).

Linear correlation between two parameters is usually estimated using Pearson’s correlation coefficients. Values obtained for the present study are presented in Table 3.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DO Surface</th>
<th>DO Bottom</th>
<th>BOD₅ Surface</th>
<th>BOD₅ Bottom</th>
<th>COD Surface</th>
<th>COD Bottom</th>
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<tr>
<td>DO Bottom</td>
<td>1.00</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>BOD₅ Surface</td>
<td>-0.09</td>
<td>-0.11</td>
<td>1.00</td>
<td></td>
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<tr>
<td>BOD₅ Bottom</td>
<td>-0.04</td>
<td>-0.04</td>
<td>0.85</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COD Surface</td>
<td>-0.35</td>
<td>-0.36</td>
<td>0.81</td>
<td>0.67</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>COD Bottom</td>
<td>-0.45</td>
<td>-0.46</td>
<td>0.57</td>
<td>0.54</td>
<td>0.78</td>
<td>1.00</td>
</tr>
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</table>

S: surface; B: bottom
For DO and BOD$_5$ on one hand and, on the other hand, between DO and COD, correlation coefficients values were negatives in relation with their respective opposite profiles. Indeed, because of DO consumption during organic matters mineralization, the increase in BOD$_5$ and COD contents in aquatic ecosystems is generally accompanied with the decrease of DO levels. Indeed, in aquatic ecosystems, DO is the first oxidant involved in the mineralization process, so organic matter degradation. However, in the urban area of the Ebrié Lagoon, the maximum values of dissolved oxygen concentrations didn’t met lowest BOD$_5$ values, nor COD ones (Table 2). A perfect significant and positive correlation (r = 1.00; p<0.05) was observed between DO contents in surface and bottom waters (Table 3). BOD$_5$ and COD were also positively and significantly correlated in surface and bottom samples (Table 3). Indeed, according to its definition, BOD$_5$ represents a part of COD (biodegradable one) of the sample. Consequently, in general, highest values of COD meet with highest BOD$_5$ contents.

Spatial variations in DO, COD and BOD$_5$ contents seem to be the combination of several factors such as the nature and amount of the organic matter amounts, the intensity of the photosynthesis, the depth of the each sampling site, the hydrodynamics and tides occurred at the different sampling sites, etc. This could be explained by the fact that the mineralization of organic loads (biodegradable or not) from watershed introduced into receiving waters lead to dissolved oxygen consumption; despite the fact that oxygen lost through the mineralization process is often compensated with contents from aquatic flora photosynthetic activity.

Differences observed between BOD$_5$ and COD values are the result of organic pollutants inputs in the Ebrié Lagoon. These ones seem to be non-biodegradable for the majority as indicated by the COD/BOD$_5$ ratio’s values obtained (Table 2). Such components are likely to seriously threaten the marine organisms’ lives in general, and especially which of benthic organisms such as mollusks. Indeed, in addition to hypoxia (often anoxia) conditions observed some organic pollutants mineralization that contain nitrogen element (N) and sulfur (S) produce ammonia (NH$_3$), sulfide hydrogen (H$_2$S), etc. Such components seriously threaten all forms of aquatic life.

B. Seasonal Variations of DO, BOD$_5$ and COD Concentrations

In surface waters such as lagoons, some physicochemical levels depend on the type of dilution waters origins that qualities vary with seasons. For the present study, seasonal variations observed for DO, BOD$_5$ and COD concentrations are respectively represented by Figures 3a, 3b and 3c. For both seasons, highest contents in DO were observed in surface waters on one hand, and, on the other hand during the dry season. Lowest values were recorded during the rainy and flood seasons (Fig. 3a). Similar observations were made by Yao et al. (2009). Dilution waters from runoff and Comoé River carry several organic materials which are finally introduced in Lagoon waters, accompanied with DO depletion due the mineralization process that followed effluents inputs.

Seasonal variations of BOD$_5$ contents respectively in surface and bottom waters were in the following ascending ranks: Dry Season < Rainy Season < Flood Season; Flood Season < Dry Season < Rainy Season (Figure 3b). In surface waters, the highest value (168.5mgO$_2$/L) was recorded during Flood Season while the lowest (93.5mgO$_2$/L) was recorded for the Dry Season (Figure 3b). The seasonal average values of BOD$_5$ ranged from 93.05 to 168.5mgO$_2$/L in surface waters and from 92.15 to 105mgO$_2$/L in those of the bottom. For COD, seasonal variations observed both in surface than in bottom waters were in the following descending ranking: Food season > Dry Season > Rainy Season (Fig.3c). Lowest concentrations of COD observed for rainy season is due to dilution effect occurred by rainfall waters. The seasonal average values of COD varied from 372.80 to 865mgO$_2$/L and from 549.31 to 971.83mgO$_2$/L respectively in surface and bottom waters. Highest values of COD values were observed in bottom waters for both seasons (Figure 3c). Highest values of BOD$_5$ and COD were observed at Milliardaires Bay (S1 and S2), a consequence of its continuous urbanization and farming activities (Table 2; Figure 3c). Indeed, in the absence of any sanitation system at that Bay, all wastewaters from anthropogenic activities are introduced into these waters without any treatment. Les faibles valeurs de DCO observées pendant la saison des pluies s’expliquent par l’effet de dilution induit par les apports d’eaux pluviales. In contrast, during Flood Season, waters from coastal rivers and mainly those from Comoé River are sources of hardly biodegradable organic pollutants such as pesticides, POPs, PAHs, pharmaceuticals, etc. from anthropogenic activities (domestic, agricultural, medicinal, transport, portuary, etc.) regarding the Ebrié lagoon.
IV. Conclusion

The aim of the present study was organic pollution assessment in Ebrié Lagoon waters around Abidjan City on the basis of DO, BOD, and COD measurements. Hypoxia situations were observed in urban bays (Banco, Cocody and Marcory) closed to Abidjan City in general, and particularly in bottom waters. BOD and COD values were higher indicating organic pollution of the studied area. This pollution was highlighted by lowest DO concentrations observed in sites where maximum values of BOD and/or COD were observed. According to DCO:DBO ratio values, highest values of this parameter indicated that organic matter introduced in Ebrié Lagoon waters was not easily biodegradable. Such hazardous components add to DO contents depletion is harmful for marine organisms. Significant differences were observed between different sites due to diffuse effluents of each site. Seasonal variations were also observed with highest COD values observed during flood season while waters from Comoé River dilute Ebrié Lagoon waters. Ces résultats montrent que les eaux de ruissellement et fluviales sont des sources de polluants organiques dangereux pour la vie aquatique. Par conséquent, la protection des eaux de la lagune Ebrié est liée au contrôle de l’ensemble des différentes sources de pollution. These results show that the runoff waters and are sources of hazardous organic pollutants for aquatic life. Therefore, the protection of Ebrié lagoon waters is linked to the control of all of its sources of pollution.

V. References